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PRODUCTION AND QUALITY OF *Physalis peruviana* FRUIT APPLYING DIFFERENT DOSES OF SIMPLE SUPERPHOSPHATE IN THE SOUTHERN REGION OF MINAS GERAIS, BRAZIL

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Abstract

The present study aimed to investigate and determine the most relevant fertilization levels of Simple Superphosphate to increase fruit production and improve fruit quality for fresh consumption. The experiment was conducted at the EPAMIG Experimental Field in Lambarí, Minas Gerais, from September 2021 to November 2022. Five fertilization levels were tested: 150 grams/plot, 300 grams/plot, 600 grams/plot, and 1200 grams/plot, along with a control group (no fertilization). A significant increase in fruit production was observed at the higher dose (1200 grams/plot) compared to the control, representing a 54.06% increase in fruit production. Additionally, the total fresh biomass production increased by 19.43%, the number of primary and secondary branches per plant increased by 48.99%, the branch length increased by 4.26%, and the canopy diameter increased by 6.83% when compared to the control. All these characteristics were significantly different at the 95% confidence level according to the Scott-Knott test. We concluded that 300 grams/plot was the best fertilization dose to achieve higher production and acceptable quality.

Keywords: goldenberry; peruvian groundcherry; aguaymanto; uvilla; solanaceae.

PRODUÇÃO E QUALIDADE DO FRUTO DE *Physalis peruviana* APLICANDO DIFERENTES DOSES DE SUPERFOSFATO SIMPLES NA REGIÃO SUL DE MINAS GERAIS, BRASIL

Resumo

O presente estudo teve como objetivo investigar e determinar os níveis de fertilização mais relevantes de Superfosfato Simples para aumentar a produção e melhorar a qualidade dos frutos para consumo in natura. O experimento foi conduzido no Campo Experimental da EPAMIG em Lambarí, Minas Gerais, de setembro de 2021 a novembro de 2022. Foram testados cinco níveis de fertilização: 150 gramas/parcelas, 300 gramas/parcelas, 600 gramas/parcelas e 1200 gramas/parcelas, além de um grupo controle (sem fertilização). Observou-se um aumento

significativo na produção de frutos na dose mais alta (1200 gramas/parcelas) em comparação ao controle, representando um aumento de 54,06% na produção de frutos. Além disso, a produção total de biomassa fresca aumentou 19,43%, o número de ramos primários e secundários por planta aumentou 48,99%, o comprimento dos ramos aumentou 4,26% e o diâmetro da copa aumentou 6,83% em comparação ao controle. Todas essas características foram significativamente diferentes ao nível de confiança de 95%, de acordo com o teste de Scott-Knott. Concluímos que 300 gramas/parcelas foi a dose de fertilização ideal para alcançar maior produção e qualidade aceitável.
Palavras-chave: goldenberry; physalis; aguaymanto; uvilla; solanáceas.

Introduction

Currently, Colombia is the largest producer of *Physalis* spp. (Solanaceae), the fruit being the second most exported product, supplying the North American, European, and Latin American markets (Rodrigues *et al*., 2020). Research on the nutrition of *Physalis* spp. in Brazil is limited, and fertilizer recommendations are often based on results from other regions or the tomato crop, as it belongs to the same plant family Solanaceae (Moura *et al*., 2016). Thus, fertilizer recommendations become necessary to improve fruit quality and productivity (Santos *et al*., 2019). Phosphorus plays an important role in the transfer of energy within cells. Its deficiency results in decreased fruit productivity and causes alterations in metabolic functions. The initial symptoms of deficiency include a dark green or bluish-green hue in the leaves, which later develop purplish-red pigments and brown spots (Hoyos; Fonseca, 2019).

Physalis spp. is an herbaceous plant that ranges from 1.5 to 2.0 meters in height (Rufato *et al*., 2012). Its fruit is a globular berry ranging from 1.5 to 2.5 cm in diameter, weighing between 4 to 10 g, with coloration that changes from green to orange when ripe, and they are surrounded by an inflated, accrescent calyx (Fischer; Almanza-merchán; Miranda, 2014). Its leaves are velvety and triangular, with hairy petioles (Alvarenga *et al*., 2016). It produces primary and secondary metabolites that give it anti-inflammatory, antioxidant, anticancer, and antidiabetic properties (Medina *et al*., 2019).

Depending on cultural practices and the cultivated region, it can yield up to 14 t/ha in the first year of harvesting, with a lifespan of two to three years, and fruit production starts around 120 to 150 days (Rufato *et al*., 2012; Rodrigues *et al*., 2013). Throughout its domestication process, factors such as soil fertility, training system, spacing, and planting conditions have started to directly influence the quantity of fruits harvested per hectare (Veasey *et al*., 2011). Harvesting is done twice a week depending on fruit ripe stage, and the production system can be managed directly in open fields or in protected environments. The most used species in commercial fields are

Physalis peruviana and *P. angulata*, being some species of the genus *Physalis* native to Brazil, including in the North, Northeast, and South of Minas Gerais (MG).

Proper nutrition of *Physalis* spp. plants is crucial to ensure product quality and achieve high crop yields, even for export. Therefore, the aim of this study was to evaluate the effect of increasing doses of simple superphosphate on vegetative growth, fruit production, and fruit quality of *P. peruviana*.

Materials and Methods

The experiment was conducted at the EPAMIG Experimental Field in Lambarí, MG, from September 2021 to December 2022. The municipality has a CWA climate classification according to Köppen, characterized as warm temperate (mesothermal) with a dry winter and rainy summer. It has an average annual temperature of approximately 19.2°C, an average relative humidity of 75%, an annual total precipitation of around 1744 mm, and an average altitude of 1100 meters.

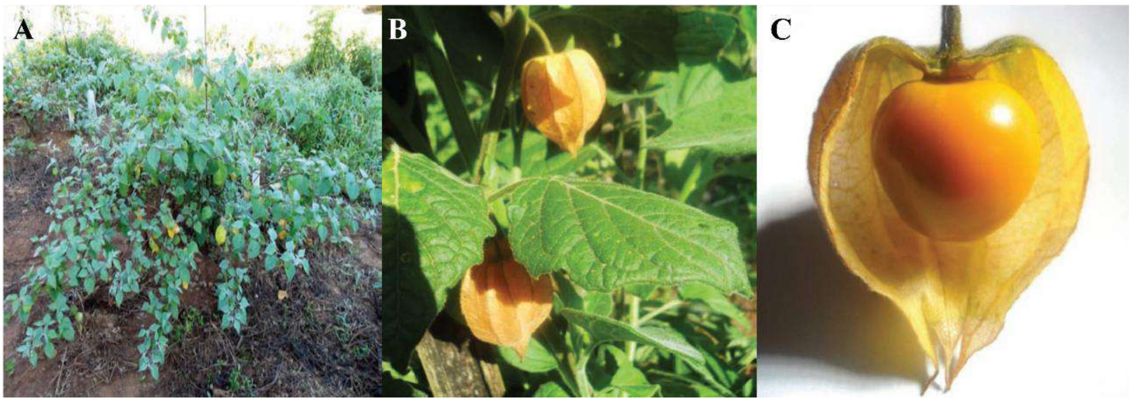
The experimental design was completely randomized with five treatments and four replications, totaling 20 plots with a useful area of 3.60 m^2 each. Treatments included five levels of simple superphosphate (SSP): 150 g/plot, 300 g/plot, 600 g/plot, 1200 g/plot, and a Control treatment (water application only).

For seedling production, seeds were extracted from ripe fruits with standard size, intense orange color and a pronounced flavor. The fruit consists of a fleshy globe-shaped berry with a diameter ranging from 1.25 to 2.50 cm and a fresh mass of 4 to 10 grams, containing about 100 to 300 seeds. The suitable moment for seed extraction is when the calyx shows a yellowish-green color (Gordilho, 2003). The seeds were rinsed using water to remove all mucilage and dried in the shade at room temperature. The seeds were sown directly in bags inside a greenhouse in July and transplanted in October.

The experiment was conducted in a sunny area with easy access and irrigation. Soil fertility correction was carried out by applying lime directly to the planting pit thirty days before planting the seedlings. After planting the seedlings, an irrigation system was installed with a drip tape for each plant row. The experiment was conducted with a spacing of 3.0 m between rows and 1.20 m between plants. Two *P. peruviana* seedlings were planted per pit in a free-conduction system between the plants, which is commonly used on small farms.

For plant management, only cleaning pruning of branches with diseases, dry leaves, and thinning of branches at the base of the plant was performed. *Physalis* spp. fruits should be harvested when the calyx turns orange, indicating ripeness. Additionally, harvesting the fruits with the calyx intact maintains fruit durability, ensures hygiene, and prevents mechanical damage during harvesting (Figure 1A - C).

Figure 1. *Physalis peruviana* plant (A), inflated calyx enclosing fruit (B), and open calyx showing the fruit.



The following characteristics were evaluated fifteen days after transplant: the number, diameter, and length of branches, canopy diameter, fruit production, and analysis of the internal pulp of the fruits. The data were subjected to analysis of variance, and in cases of significant differences, means were compared using the Scott-Knott test at a 5% significance level.

Results and Discussion

The fertilization levels significantly influenced the characteristics analyzed (Table 1 and Table 2). Phosphorus is a limiting nutrient in crop productivity, playing an important role in the transfer of energy within cells (Hoyos; Fonseca, 2019) and aiding in the better utilization of water and other nutrients (Ali; Singh, 2017). An increase in the SSP dose, induced an increase in total fruit production, the number and diameter of branches, branch length, and vegetative fresh biomass. A total fruit production 54.06% higher was observed when applying 1200 g/plot, reaching a peak production of 5,699.65 kg/plot (Figure 2). With increasing SSP dose, there was a 48.99% increase in the number of branches per plant (Figure 3), as well as an 19.43% increase in fresh vegetative biomass (Figure 4), and 4.26% longer total branch length for rooted seedling propagation (Figure 5). With the application of 300g/plot, production was 36.16% higher compared to the control, and most important, a pH index of 3.63 (Figure 6).

Table 1. Total fruit production (TFP), number of branches (NB), diameter of branches (DB), total branch length (TBL), and vegetative fresh biomass (VFB).

Treatment	TFP (g)	NB	DB (mm)	TBL (m)	VFB (kg)
0	2.610,08 b	19,16 b	16,23 b	17,75 c	2,86 b
150	2.779,66 b	19,02 b	16,35 b	17,82 b	2,87 b
300	3.638,25 b	19,41 b	16,60 b	18,06 b	2,94 b
600	3.645,25 b	29,50 a	16,71 b	18,43 a	3,24 a
1200	5.699,65 a	37,37 a	17,42 a	18,54 a	3,55 a
CV (%)	24,14	24,58	2,95	3,84	8,69

Note: means followed by the same letter in the same collum do not differ from each other, using the Scott-Knott test, at 5% probability levels.

Table 2. Soluble solids of *Physalis peruviana* fruits, titratable acidity (TA) pH and BRIX.

Treatment	Soluble solids		
	TA%	pH (%)	BRIX
0	1,68 a	3,30 b	12,63 a
150	1,59 b	3,39 b	11,66 b
300	1,41 b	3,63 a	10,82 b
600	1,40 b	3,47 b	9,72 b
1200	1,27 b	3,48 b	9,70 b
CV %	10,30	3,88	11,41

Note: means followed by the same letter in the same collum do not differ from each other, using the Scott-Knott test, at 5% probability levels.

Figure 2. Total fruit production of *Physalis peruviana* in the different simple superphosphate doses. Means followed by the same letter do not differ from each other.

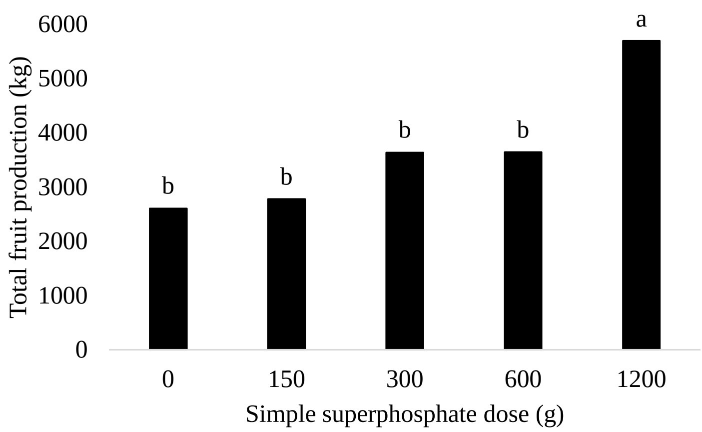


Figure 3. Number of branches per plant of *Physalis peruviana* in the different simple superphosphate doses. Means followed by the same letter do not differ from each other.

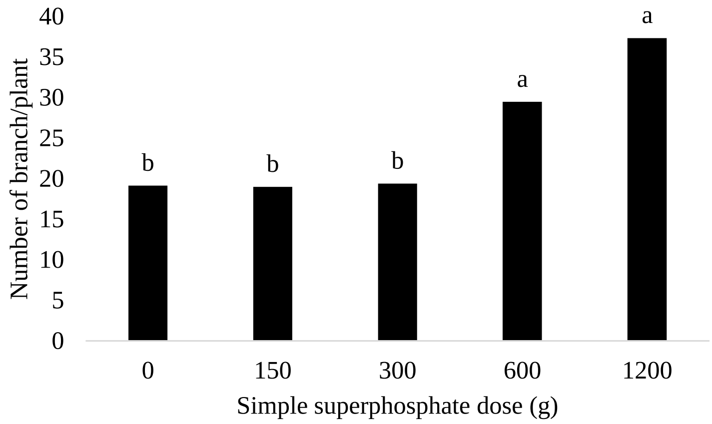


Figure 4. Vegetative fresh biomass of *Physalis peruviana* in the different simple superphosphate doses. Means followed by the same letter do not differ from each other.

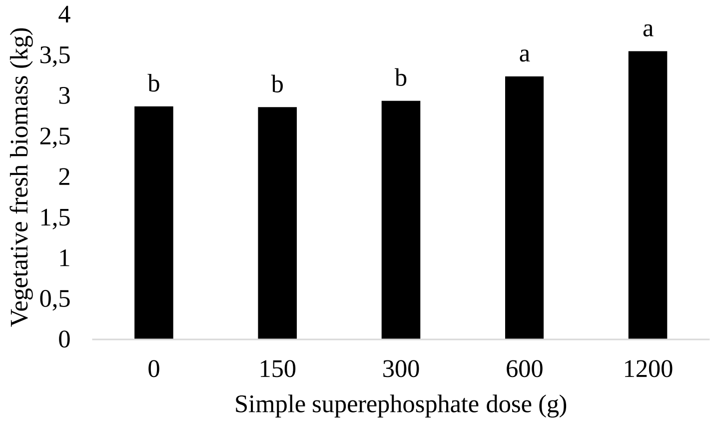


Figure 5. Total branch length of *Physalis peruviana* in the different simple superphosphate doses. Means followed by the same letter do not differ from each other.

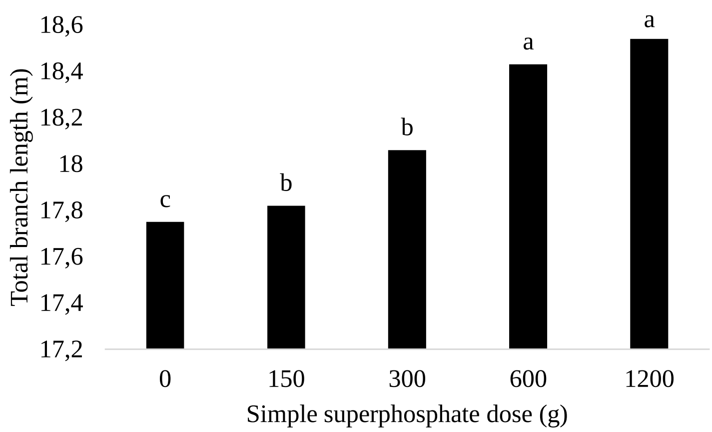
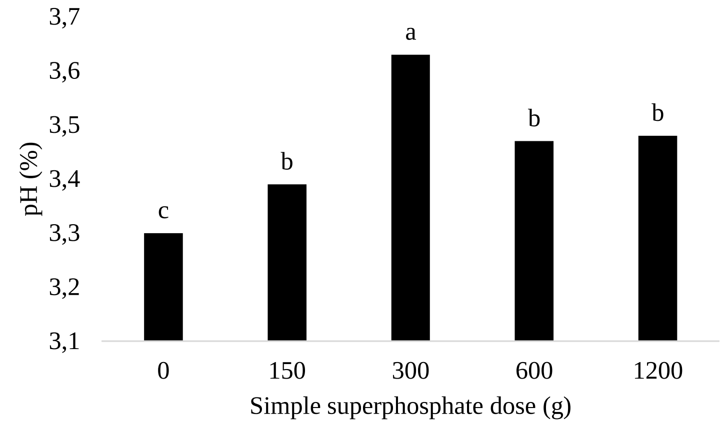


Figure 6. Fruit pH in the different simple superphosphate doses. Means followed by the same letter do not differ from each other.



The length of the main branches can reach eight to twelve nodes and can naturally bifurcate, giving rise to productive secondary branches of the plant. We observed that increasing doses of SSP ensured greater branch length at the base of the plants. Additionally, a greater amount of vegetative material was observed for the propagation of new seedlings through cutting (Table 1).

Phosphorus deficiency produces effects like nitrogen (N) deficiency, with plants having thin stems, small leaves, reduced flowering, and delayed floral bud opening (Santos *et al*., 2019). It was observed that with the application and incorporation of SSP, there was an increase in branch diameter compared to the control (Table 1). When a dose of 1200 grams of SSP was applied, there was a 19.43% increase in vegetative fresh biomass.

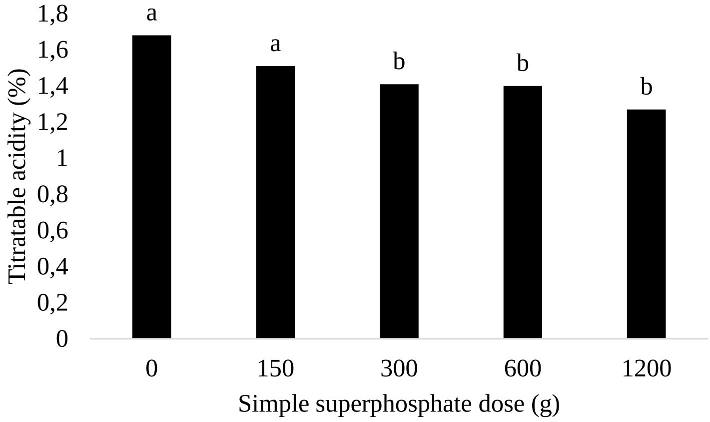
Table 2 shows the physicochemical analyses of titratable acidity (1.68%) and ºBrix (12.63%) of *P. peruviana* fruit pulp and show that the control had superior results compared to the other treatments. On the other hand, pH percentage (3.63%) was higher with the application of 300 (g)/plot of SSP.

According to the (Codex Stan, 2005), *Physalis* spp. fruits should have a minimum of 14ºBrix to be marketed. Additionally, all fruits should meet other requirements such as mass, color, and diameter to be sold. According to (Rodriguez, 1995), in Santiago, Chile, values of 12.10º Brix were observed in fruits from trellised plants. In Lambari-MG, using the free-conduction system, higher fruit quality levels were observed, with a ºBrix index of 12.63%. It can be observed that with increasing fertilizer doses, there is a decrease in sugar concentration in the fruits, which reduces their quality for fresh consumption. The ideal dose of SSP for *Physalis* spp. production, considering the production of higher-quality fruits, would be around 300 (g)/plot of SSP.

It was observed that the control had the highest sugar content in the fruits, and the higher fertilizer doses had lower sugar content in the fruits. Thus, the 300g/plot fertilization dose was the most suitable among the applied treatments to produce higher-quality fruits (Table 2).

In all treatments, a decrease in titratable acidity was observed with increasing doses of SSP, except in the control. Titratable acidity was determined by titration, and results expressed as a percentage in fresh pulp (Figure 7).

Figure 7. Titratable acidity of *Physalis peruviana* fruit in the different simple superphosphate doses. Means followed by the same letter do not differ from each other.



Conclusion

In conclusion, with higher application of SSP, there was an increase in fruit production, a decrease in ºBrix, and lower titratable acidity. This leads to a decrease in the quality of *Physalis peruviana* fruits. Conversely, the control showed a higher concentration of total sugars (ºBrix) and higher titratable acidity in the ripe fruit, which may lead to greater acceptance in the fresh market.

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